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Shear softening above jamming

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ABSTRACT

We investigate experimentally the mechanical response of a monolayer of frictional grains to an inhomogeneous shear perturbation across the jamming transition. We inflate an intruder inside the packing and use photoelasticity and tracking techniques to measure the induced shear strain and stresses at the grain scale. We quantify experimentally the constitutive relations for strain amplitudes as low as 10^{-3} and for a range of packing fractions within 2% variation around the jamming transition. At the transition strong nonlinear effects set in. The dependencies of the critical strain and the associated critical stresses on the distance from jamming are extracted via scaling analysis. We check that the constitutive laws, when applied to the equations governing mechanical equilibrium, lead to the observed stress and strain profiles. These profiles exhibit a spatial crossover between an effective linear regime close to the inflator and a truly nonlinear regime away from it. The crossover length diverges at the jamming transition.